# THE RELATION OF THE TECHNIQUE OF NURSES AND OF HOSPITAL APPARATUS TO THE HEALING OF WOUNDS.

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It is the general belief of surgeons that infection in wounds, almost without exception, occurs in the operating-room as a result of introducing pathogenic microörganisms into wounds upon the hands of the surgeon or his assistants, or by means of the instruments or suture material or dressings employed. This belief has become general since the older theory that germs usually come in contact with wounds by means of the air was disproved. This source of contagion is believed to be a possibility, but practically to play a very small role in infection. This belief was held by myself and served as the practical basis of my own work until from experience I became convinced that the theory was not sufficiently broad to cover all the facts in hospital practice.

Some time ago, having occasion to investigate a series of infections occurring in clean wounds, I was driven to the conclusion that the infections did not occur in the operating-room, and upon careful investigation was satisfied that they were due to errors in technique on the part of the nurses, either before or after the patients had been operated upon. This experience led me to study the question of the technique of nurses and of the apparatus supplied to nurses in hospitals with which to perform their duties. It also led me to consider the wisdom of the plan usually followed by surgeons, including myself, of giving verbal orders to the head nurse in charge, and depending upon her to maintain a proper technique on the part of the pupil nurses.

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[1] Read before the Philadelphia Academy of Surgery, May 7, 1906.

In this particular investigation I learned that the technique in use was quite different from what I believed it to be. Verbal orders had been given for many years, modified by other verbal orders from time to time, so that it was not surprising that the result of such a method should be a lack of exactitude in detail in carrying out general principles.

As a result of this experience I determined to adopt a technique which should be printed, so that there could be no question upon the part of the head nurse as to what was required, and no possibility on the part of any pupil nurse of misunderstanding the instruction of the head nurse.

With the assistance of the hospital staff a technique was compiled which was submitted to various head nurses for suggestions, and was used for a year so that it might be corrected by practical experience before being printed and finally adopted.

The result of this experiment, which I believe is novel, has been most satisfactory to all concerned. The long-continued series of infections which led to the investigation was promptly cut short and for nearly a year primary union was obtained, without exception, in non-suppuration cases.

During this particular series of infections already referred to, the same operating-room technique was employed which had been in use for a long time, with the result of obtaining primary union without suppuration in 98 per cent. of cases. When the infections began to occur, it was naturally supposed that this was due to carelessness on the part of some one connected with the operating-room. The personnel was gone over, every one was stimulated to rigid care in every detail of asepsis, with no improvement in the results secured. The sterilizing apparatus connected with the operating-room was overhauled and put in perfect order, and the time devoted to the sterilization of instruments, dressings, etc., and the disinfection of the hands was doubled, without result. Also the preparation of the field of operation was made more rigidly. These facts led me to consider whether it was possible for the wounds to become infected elsewhere. A peculiarity of the series of infections was that as a rule they were mild. The mortality during the series, which extended over a number of months, was not increased. There were no cases of peritonitis in a long series of abdominal sections, and the infections as a rule occurred late and were confined chiefly to the subcutaneous fat. Finally, not only celiotomy wounds, but those of Alexander operations, hernias and eventually plastic operations upon the uterovaginal canal likewise became infected.*

Upon investigating the technique in use in the wards of the hospital I found evidence that the hands of the nurses were not adequately disinfected, that the douche bags were not sterilized, sterilization being limited to the douche-nozzle; that the basins and trays employed were not systematically sterilized (dependence being placed upon the solutions they contained for their sterilization), and that the methods in use for sterilization were far from satisfactory; also that the bath-tubs, while clean in the domestic sense, were not disinfected. It seemed to me to be a rational conclusion that patients being admitted to the hospital and given two or three baths in a bath-tub presumably septic, before being operated upon, and being prepared for operation by the hands of nurses which were not sufficiently disinfected, enough pathogenic microörganisms became implanted upon the skin of the patients to explain the series of infections. In order that this theory should be tenable it was, of course, necessary that the bath-tubs and the apparatus used by the nurses should have been infected from some patient early in the series of infections. In order to test the matter, rigid regulations as to the sterilization of all the apparatus used by the nurses, the disinfection of the bath-tubs and of the nurses' hands, were at once instituted and the usual technique of sterilization formerly in use in the operating-room was reverted to; that is, the amount of sterilization in the operating-room was cut down one-half. The result was immediate. The infections disappeared and the series was at an end.

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* During the time that the infections were occurring in the hospital, the same assistants, dressings and suture material were used repeatedly in operations elsewhere without infection occurring in wounds. It was this fact which finally induced me to look elsewhere than in the operating-room for the source of the difficulty.

It seems to me that the demonstration was complete that this series of infections came about in the way suggested. It has long been known that it is impossible to sterilize a surgeon's hands infected with virulent microörganisms by any means at our command, without a period of two or three days having elapsed since the infection took place. As a concrete example of this fact, in the early days, probably every abdominal surgeon had the experience of performing a celiotomy within one or two days after having examined a woman suffering from puerperal septicæmia, or having operated upon an abscess containing streptococci and of having the unhappy experience of seeing his patient contract a virulent septic peritonitis, with a fatal termination. The conditions were entirely similar in principle. The skin of the patient was infected with pyogenic microörganisms from the bath-tub or the nurse's hands, and the subsequent efforts at disinfecting the field of operation within the next day or two days were insufficient to render the field entirely sterile. The number of germs introduced in any case was insufficient to cause a fatal peritonitis, but did bring about suppuration in the wounds.

It seems to me that this demonstration is of sufficient importance to bring it to the attention of surgeons who, in general, like myself, have been convinced that to prevent suppuration in wounds it is only necessary to maintain a rigid technique in the operating-room.

Being convinced of the facts in the case, I investigated the nature of the apparatus in use by the nurses and the facilities afforded them to sterilize the same efficiently, and also the facilities afforded them for disinfecting their hands, when it became evident that these facilities were by no means adequate to obtain the best results. I therefore determined to institute a radical change. The problem was to eliminate all apparatus which could not be sterilized by boiling, to provide proper sterilizers by means of which all apparatus could be sterilized, and to study the problem of how the hands of the nurses could be kept from contact with infected objects, and, in addition to this, to prescribe rigid regulations for the disinfection of the hands of the nurses. It required but little study to determine that, as hospitals are usually conducted, the hands of the nurses are constantly coming in contact with infected objects; for example, bed-pans are constantly receiving infected dejecta from the bowels, douche-pans are constantly receiving infected discharges from the genitalia, pus-basins and vomit-trays likewise are constantly handled by nurses, and the provision for the systematic sterilization of these utensils is lamentably poor or entirely absent. It was at once clear that if the hands of the nurses are to be kept free from contact with septic objects all such apparatus must be systematically sterilized.

It was clear also that under the usual conditions obtaining in hospitals all the objects about the wards with which the hands of the nurses come in contact might prove sources of infection, and that all such objects must be systematically disinfected.

A sterilizing plant was installed in the bath-room upon each floor sufficiently large to contain a dozen bed-pans or douche-pans. By means of high-pressure steam these can readily be sterilized by boiling. A rule was adopted that all bed-pans and douche-pans should be sterilized once daily, and thereafter stored in a clean closet until used. After use they are washed out in the usual way and drained. This prevents the carrying over of infection from one day to another. It would, of course, be more ideal if they were sterilized each time after use, but this was deemed to be an unnecessary nicety in practice. The point was to prevent carrying over infection from time to time or from one case to another. In addition to this, the customary rule that the apparatus in use upon septic patients should be isolated, was, of course, continued. A sterilizer similar to that used in operating-rooms for the sterilization of instruments was installed in each diet-kitchen, so that all of the basins and trays, catheters and instruments used by nurses can be sterilized as efficiently as is done in the operating room.

A rule was adopted that all basins, pitchers and trays used by nurses shall be cleaned and boiled for ten minutes after use, and then stored in formaldehyde solution 1–4000; also that this solution shall be changed daily. All bowls for solutions must be again boiled before using. A general rule was adopted that all apparatus used by nurses must be sterilized at least once daily.

A definite technique for the disinfection of the nurses' hands was adopted, as follows: The hands shall be scrubbed for three minutes with soap and water and a sterile nail-brush. The finger-nails shall then be cleaned with a sterile wooden nail-cleaner, and the hands shall be scrubbed again for three more minutes. The hands shall then be soaked in formaldehyde solution 1–500 or bichloride of mercury solution 1–1000, for two minutes.

As a further precaution against the possibility of infecting the skin of patients admitted to the hospital, in addition to preparing for the disinfection of the bath-tubs and the nurses' hands, a plan was adopted of having all patients prepared for operation during a certain period by a nurse assigned for that duty, called the preparing nurse, whose hands are thus kept from contact with septic material.

In applying the general principle of keeping the hands of the nurses free from septic material there were numerous details to be worked out, some of which have been met as follows: It is required that, after the usual daily cleaning by the ward maid, the door-knobs, window-sills, tables, chairs, bureaus, bedsteads, poles for douche-bags, and the tops of all furniture or objects in the wards or rooms, shall be wiped off with formaldehyde solution 1–500 by the nurse; also, that all shelving in the diet-kitchens and in the rooms in which the apparatus for nurses is kept, shall be washed daily; on alternate days with soap and water, and with formaldehyde solution 1–500.

Among other objects with which the hands of the nurses come in daily contact there are probably none which are more septic, if not absolutely dirty, as hospitals are usually conducted, than the rubber sheets which are used to protect mattresses. The usual method of caring for these is to wipe them off when the patient is discharged and then to put them on another bed; and it is quite probable that even this wiping off process is often omitted. As these sheets necessarily receive discharges from the bowels, from the vagina, and from discharging wounds in many cases, from the necessities of the situation they must always be covered with pathogenic microörganisms and are, therefore, a fruitful source of infection of the hands of nurses.

Such rubber sheets are treated by washing them thoroughly after use, after which they are soaked in formaldehyde solution 1–500 for twelve hours, wiped dry and put away in a sterile cloth, rolled on a roller, until used again.

The vomit-trays and pus-basins were eliminated as sources of infection of the nurses' hands by classing them with the other basins and trays in use, and having them cleaned and sterilized and stored in formaldehyde solution each time after use.

Another source of infection of the nurses' hands are the cans which are used to receive the dressings and waste from the wards. Such cans are in constant use in all hospitals, and receiving, as they do, septic dressings, they are a prolific source of infection of the nurses' hands. This source of infection was eliminated by requiring that the lids of the cans should be permanently removed, so that it is unnecessary for the nurse to touch the cans. When the cans are taken to the engine-room in order that their contents may be burned, they are cleaned, and then boiled in an apparatus installed for the purpose. This is done by the engineer force, and it requires but a few minutes when the apparatus is installed; and it eliminates one source of filth and infection with a minimum expenditure of time and effort.

In the operating-room some additional apparatus was installed to insure the absolute daily disinfection of every article in use in the operating-room. With the modern pressure-steam dressing-sterilizer and instrument-sterilizer there is no longer any difficulty in adequately sterilizing dressings, instruments, towels, gowns, etc., but for convenience a large instrument-sterilizer similar to the ones designed for the sterilization of bed-pans, douche-pans, etc., was installed in the sterilizing-room, which will contain a sufficient number of basins, pitchers, etc., to furnish sterilized basins for a day's work.

A new apparatus was installed by means of which the hands of the surgeon and his assistants are washed in a spray of running water—the supply of water being controlled without using the hands. This apparatus eliminates the possibility of infecting the hands by washing them in septic basins.

In my judgment every hospital should install a plant which will sterilize its entire water-supply. Hospitals having a high-pressure steam plant can do this with very little expense by having the cold-water inlet-pipe pass through a cylinder sufficiently filled with copper tubes connected with the high-pressure steam plant to boil and sterilize the water on its way to the storage-tank. By regulating the size of this tank and the amount of heating surface in the copper coils to the daily amount of water used, it is a relatively simple mechanical problem to sterilize the entire supply of a hospital. An additional apparatus would be required to cool this water on its way to the storage-tank. Such an arrangement would not only assist in eliminating typhoid fever from hospitals, but would also be of material service in carrying out the principles of asepsis.

The plan so often followed in operating-rooms of using the same basins for several consecutive operations, merely washing them out between the operations, is reprehensible, and with the present facilities for sterilizing such apparatus there is no excuse for this bad custom.

The real difficulty in the sterilization of the apparatus in the operating-room was how to sterilize the irrigators, the slop-buckets, the Kelly rubber cushions, perineal pads, etc. This problem was satisfactorily solved with the assistance of a mechanical engineer. The largest slop-can, with the smaller put within it, is filled with water and by means of a metallic connection with a high-pressure steam-pipe, live steam is turned into the water and the entire apparatus is sterilized by boiling. The Kelly pads are sterilized by soaking them over-night in formaldehyde solution 1–500, after thoroughly cleansing them. The problem of how to deal with irrigators was solved by using large rubber douche-bags, which are boiled each day before being used.

The points to which I would direct attention are:

1. Whether surgeons should be satisfied with the policy of giving verbal directions to head nurses about the disinfection of hospital apparatus and the technique of nurses as applied to the treatment of wounds; or, whether each hospital should adopt a routine technique which should prescribe the methods which are to be followed, thus avoiding any possibility of error on the part of the head nurse and pupil nurses.

2. The importance of preventing the infection of the hands of nurses by the elimination of all possible sources of contamination, through proper regulations as to the cleansing and disinfection of wards, rooms, furniture and apparatus employed by the nurses.

3. The adoption of a proper technique for the disinfection of nurses' hands.

4. The installation of proper sterilizers, which will enable nurses to sterilize the apparatus used by them as efficiently as is done in operating-rooms at the present time.